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PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(b)(2).

Docket Number		Type a plus sign (+) inside this box ☐	+
697002			

INVENTOR(s)/APPLICANT(s)

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TITLE OF THE INVENTION (280 characters max)

ADAPTIVE THRESHOLDING TO IMPROVE AVERAGE COLOR EXTRACTION FOR CONTROLLING AMBIENT LIGHTING SYSTEMS

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ENCLOSED APPLICATION PARTS (check all that apply)

X	Specification	Number of Pages	6	☐	Small Entity Statement
☐	Drawing(s)	Number of Sheets	0	☐	Other (specify)

METHOD OF PAYMENT (check one)

		PROVISIONAL FILING FEE AMOUNT ($)	$160.00
☐	A check or money order is enclosed to cover the Provisional filing fees		
X	The Commissioner is hereby authorized to charge filing fees and credit Deposit Account Number: 14-1270		

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

- [x] No

- [ ] Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

SIGNATURE: Gregory L. Thorne Date: 1/5/04

TYPED or PRINTED NAME: GREGORY L. THORNE

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- [ ] Additional inventors are being named on separately numbered sheets attached hereto

CERTIFICATE OF EXPRESS MAILING

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I hereby certify that this paper and/or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to the Commissioner for Patent, Alexandria, VA 22313.

Noemi Chapa — Noemi Chapa
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Atty. Docket

SRINIVAS GUTTA ET AL

697002

Serial No.

Filed: CONCURRENTLY

Title: ADAPTIVE THRESHOLDING TO IMPROVE AVERAGE COLOR EXTRACTION FOR CONTROLLING AMBIENT LIGHTING SYSTEMS

Commissioner for Patents
Alexandria, VA 22313

APPOINTMENT OF ASSOCIATES

Sir:

The undersigned Attorney of Record hereby revokes all prior appointments (if any) of Associate Attorney(s) or Agent(s) in the above-captioned case and appoints:

GREGORY L. THORNE **(Registration No. 39,398)**
c/o U.S. PHILIPS CORPORATION, Intellectual Property Department, 580 White Plains Road, Tarrytown, New York 10591, his Associate Attorney(s)/Agent(s) with all the usual powers to prosecute the above-identified application and any division or continuation thereof, to make alterations and amendments therein, and to transact all business in the Patent and Trademark Office connected therewith.

ALL CORRESPONDENCE CONCERNING THIS APPLICATION AND THE LETTERS PATENT WHEN GRANTED SHOULD BE ADDRESSED TO THE UNDERSIGNED ATTORNEY OF RECORD.

Respectfully,

Michael E. Marion, Reg. 32,266
Attorney of Record

Dated at Tarrytown, New York
this 5th day of January, 2004.

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Adaptive Thresholding to improve Average Color Extraction for Controlling Ambient Lighting Systems

Low intensity LED colors do not provide a realistic match with the colors shown on the television. For example, if the content contains 95% of black pixels and 5% of red ones, the perceived color of the television output to the human eye will be black. If however the LEDs are set to 5% red emittance, the perceived color of the wall reflection to the eye will be a dark red. Because there is no way to use LEDs for showing dark colors, a better approach would be to switch the LEDs off whenever the intensity of the extracted average color for a particular region falls below a certain threshold and switch them on again when it is above the threshold. This problem could be visualized below in Figure 1.

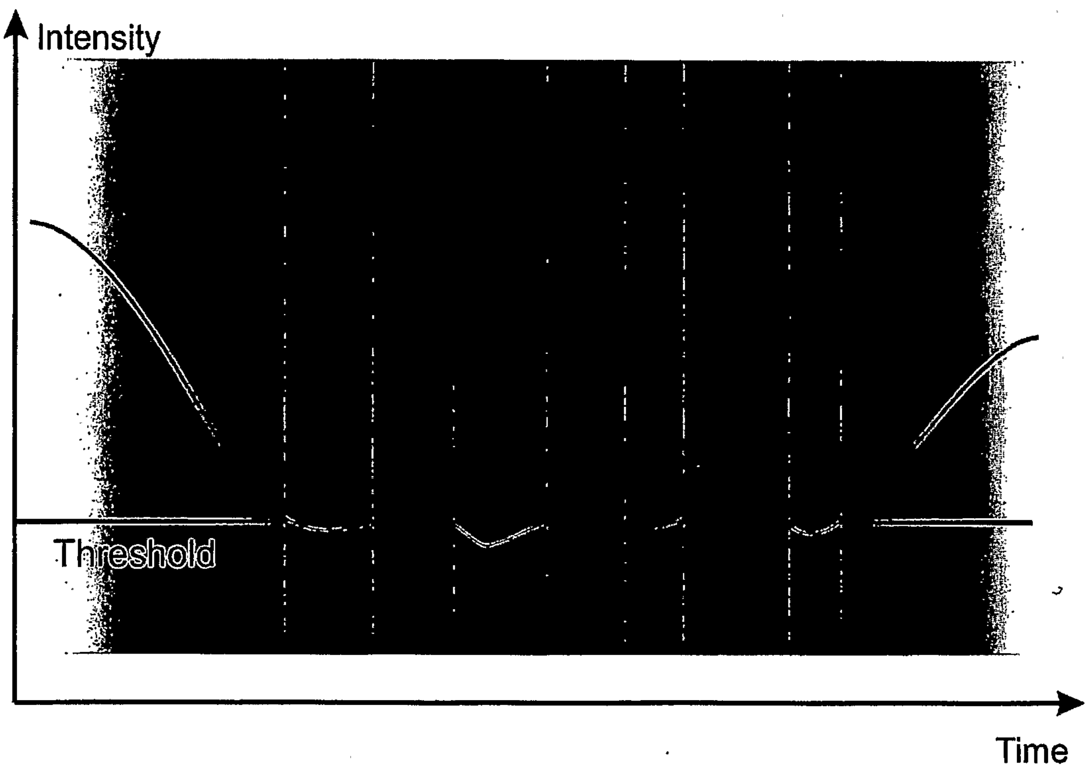

Figure 1: Output of LEDs across time

Although this way of using the threshold was an improvement, there still was a problem in cases where the extracted average color intensity fluctuates around the threshold value. In such a case the LEDs were switched off and on repeatedly, sometimes several times in a second, which led to a very annoying flickering experience. Thus we define a two-band approach where in, when the LEDs fall below an initial threshold they are switched off and they are switched on again when they are above both the initial and the secondary threshold (see Figure 2.).

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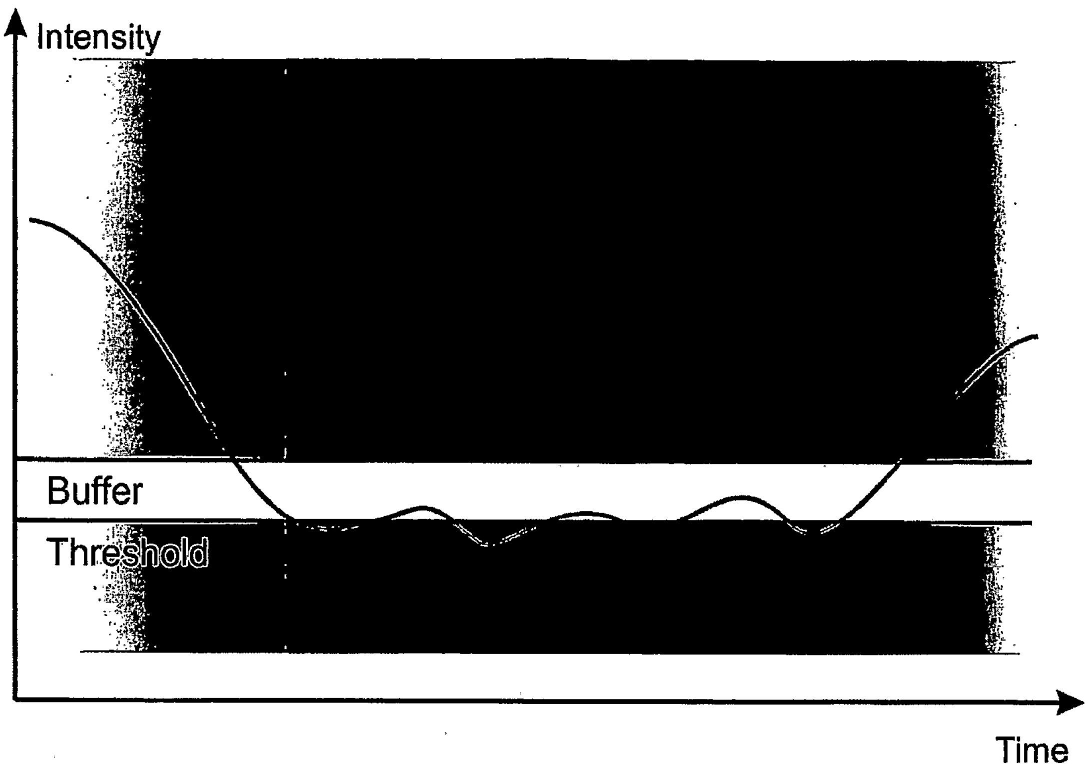

Figure 2. Buffered Thresholding

The general steps that need to be followed to realize the invention are as follows:

1) Acquire a video signal and decode the video signal into a set of frames
2) Extract color information from the content (frames) around the boundary
3) Transform the color information of the content from the RGB space onto the color space of the LEDs and the displays color space.
4) Perform gamma correction negation
5) Threshold the color output
6) Transmit the thresholded color output to the LED units so as to trigger them.

Steps (1) and (6) are straightforward and are not further discussed below.

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The current setup for an ambient lighting system is as shown below:

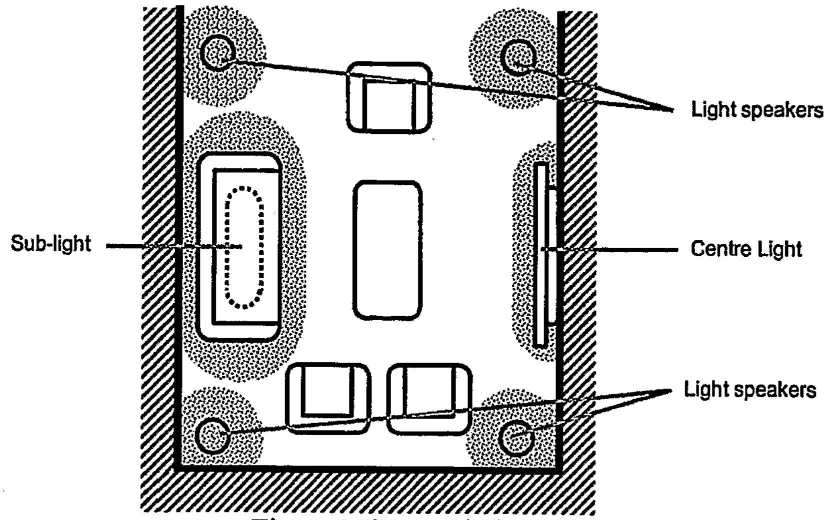

Figure 3. Setup of Light Units

In the above figure there are 11 independently controllable LED lighting units. There are four light speakers, one unit under the couch ('Sub-light') and 6 LED units on the center-light. The center-light is a little bit special, in the way it is set-up - it has 6 independently controlled, light units behind the four sides of the Flat TV and is shown below:

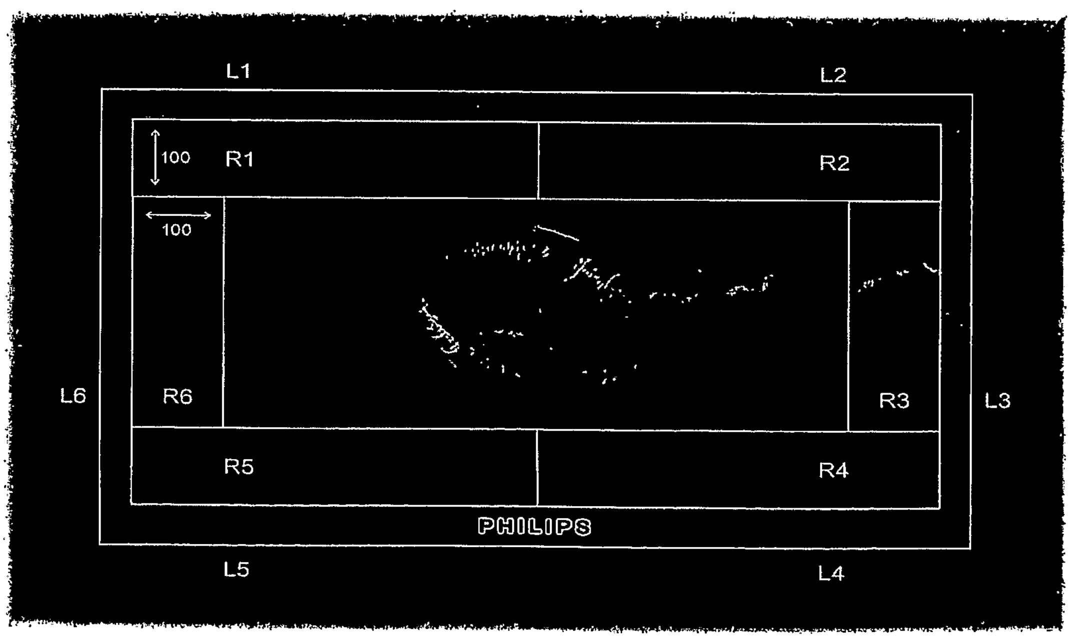

Figure 4: Setup of light units around the TV

In the above figure L1 to L6 refer to the light units around TV. The figure also shows a single frame of the content displayed on the TV. Each light unit located at the back of the

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TV is triggered by extracting the average color information from each region – R1 to R6. Each region has a width of 100 pixels. As an example if the size of the frame were 720x576 pixels, then the size of R1, R2, R4 and R5 would be 360x100 pixels. Similarly size of R3 and R6 would be 100x376 pixels.

Since the video signal is decoded into a set of frames (25 frames per second) in the RGB color space, the resulting image size would be 720x576x3 which is a 3D matrix where each 2D matrix of size 720x576 corresponds to each one of the Red, Green and Blue channels.

The average color information for each region of the channel is extracted by summing up all the pixels in that region and dividing by the total number of pixels in that region for each channel. The equation for the extraction of the average color information for each region for one channel is shown below:

$$R_{red} = \frac{\sum_{i=1,j=1}^{n,m} M_{ij}}{n \times m}$$

If the region under consideration is R1, then M_{ij} is of size 360x100 with n equal to 360 and m equal to 100. The above equation gives us the average of all the pixels for the red channel. Thus the average color for particular region would now be a triplet,

$$R_{AVE} = \lfloor R_{red}, R_{green}, R_{blue} \rfloor$$

The same procedure is repeated for all the regions and for all the channels within each region.

Next in order to set the lights, a mapping transformation needs to be performed between the TV and light units. This is achieved via a standard set of equations that take as input the measured color primaries from each LED unit. The color primaries for the red, green, blue and the reference white color components are acquired by using a color spectrometer. Once the primaries are obtained, the transformation process is as follows:

(a) Given a set of chromaticity (red, green and blue primaries) co-ordinates and the reference white, compute the transformation matrix for mapping the average color information onto the XYZ color gamut space for both the FLAT TV as well as the LED units. This gives us two set of equations :

$[X; Y; Z]=M_1 * [R;G;B]$ for Flat TV

$[X; Y; Z]=M_2 * [R';G'B']$ for LED's

(b) The mapped RGB values for the light units could be found by solving the following:

$$[R';G';B'] = M_2^{-1} * M_1 * [R;G;B]$$

In steps (a) above, [R; G; B] corresponds to the triplet which is nothing but the computed average color information for a particular region for all channels. The general method for computing the matrix M is shown below:

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Given the chromaticity coordinates of an RGB system (x_r,y_r), (x_g,y_g) and (x_b,y_b) and the white point (x_w,y_w), the method to compute the 3 x 3 matrix for converting RGB to XYZ is as follows:

$$[X\,Y\,Z] = [R\,G\,B][M]$$

where

$$[M] = \begin{pmatrix} S_rX_r & S_rY_r & S_rZ_r \\ S_gX_g & S_gY_g & S_gZ_g \\ S_bX_b & S_bY_b & S_bZ_{gb} \end{pmatrix}$$

$$X_r = x_r \qquad Y_r = y_r \qquad Z_r = 1 - (x_r + y_r)$$

$$X_g = x_g \qquad Y_g = y_g \qquad Z_g = 1 - (x_g + y_g)$$

$$X_b = x_b \qquad Y_b = y_b \qquad Z_b = 1 - (x_b + y_b)$$

$$X_w = x_w \qquad Y_w = y_w \qquad Z_w = 1 - (x_w + y_w)$$

$$[S_r \quad S_g \quad S_b] = [X_w \quad Y_w \quad Z_w]\begin{pmatrix} X_r & Y_r & Z_r \\ X_g & Y_g & Z_g \\ X_b & Y_b & Z_b \end{pmatrix}^{-1}$$

The above method is used for obtaining M_1 and M_2 and [R' G' B'] by following step (b) above. Thus [R';G';B'] is the transformed color information for a particular region. The same process is repeated for obtaining [R' G' B'] for each of the 6 regions.

The transformed color information is then accounted for gamma correction negation and this is done as follows: gamma corrected [R* G* B*] = [R$^{\wedge\lambda}$' G$^{\wedge\lambda}$' B$^{\wedge\lambda}$'], where the optimum gamma λ values has been found to be 1.8

Two different embodiments are considered for thresholding the color information. In the first case, only if all the three RGB values are below some threshold T, the corresponding LED strip will be switched off. An optimum threshold was found to be 0.05. In the case of a two-band approach, if all the RGB values are less than some threshold T, the LEDs are switched off. But, to avoid flickering, the threshold value for this particular LED strip to be switched on again, is raised to T+B. So if one of the RGB values becomes > T+B

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the LEDs will be switched on again and then the threshold value will be set back to T. Again the optimum threshold value for the two ban approach has been found to be 0.05 for T and 0,03 for B. Thus if all values < 0.05, switch off. If a value > 0.08, switch back on.

The thresholded color information is then sent to the light units so that they can be triggered. Please note that the whole process is repeated for all the frames (25) in each second. It is also important to note that the width of each region could be varied and the number of regions in the frame could also be varied. As an example, instead of using 6 regions, one could use only 4 regions as well. In such a case, the thresholded color information for the upper region could be sent to both the LED panels located at the top of the TV. Furthermore, the solution discussed above could be realized in software or via a programmable hardware platform such as EPLD, etc.

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